Chapter 3

1. Resolve vectors into west and south components
$w = 80\text{ km} + 30\text{ km} \cos 45 = 101.2\text{ km}$
$s = 30\text{ km} \sin 45 = 21.2\text{ km}$

$R = \sqrt{w^2 + s^2} = \underline{103\text{ km}}$

$\tan\theta = \frac{s}{w} = \frac{21.2}{101.2} = 0.2096$

$\theta = \underline{12^\circ \text{ south of west}}$

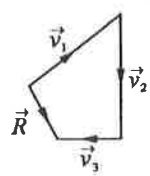
2. $y = +18 - 20 = -2$ block
$x = 10$ blocks

$d = \sqrt{(-2)^2 + 10^2} = 10.2$ block

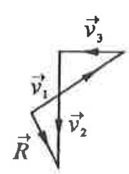
$\theta = \tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{-2}{10}\right) = -11.3^\circ$

$\theta = \underline{11.3^\circ \text{ south of east}}$

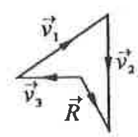
3. Use "head to tail convention" to add vectors. Note $\vec{R}$ is "wrong" way.



$\vec{v}_1 + \vec{v}_2 + \vec{v}_3 = \vec{R}$

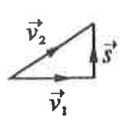


$\vec{v}_1 + \vec{v}_3 + \vec{v}_2 = \vec{R}$



$\vec{v}_3 + \vec{v}_1 + \vec{v}_2 = \vec{R}$

4. Use "head to tail" convention. Redraw.



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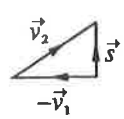


; now $\vec{s} = -\vec{v}_1 + \vec{v}_2$.

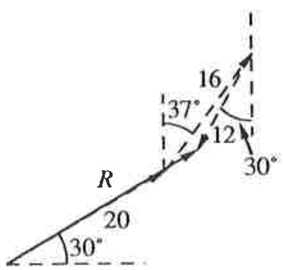
5. (a) 6.3 − 3.5 = 2.8 in x direction.

(b) 6.3 + 3.5 = 9.8 in x direction.

(c) −9.8 or +9.8 in negative x direction.

6. $v = (8.5^2 + 4.8^2)^{\frac{1}{2}} = \underline{9.76 \text{ units}}$
$\theta = \arctan(4.8/-8.5) = \underline{29.5^\circ \text{ north of west}}$

7. $\underline{R = 24 \text{ m}}$, $\underline{31^\circ \text{ N of E}}$



8. (a) $V_{1x} = \underline{0.0}$ $V_{2x} = 4.5\cos(45^\circ) = \underline{3.18}$
$V_{1y} = \underline{-6.0}$ $V_{2y} = 4.5\sin(45^\circ) = \underline{3.18}$

(b) $V_{Rx} = V_{1x} + V_{2x} = 0 + 3.18 = 3.18$
$V_{Ry} = V_{1y} + V_{2y} = -6.0 + 3.18 = -2.82$

$V_R = (V_{Rx}^2 + V_{Ry}^2)^{\frac{1}{2}} = \underline{4.25}$
$\theta = \tan^{-1}(V_{Ry}/V_{Rx}) = \underline{-41.5^\circ}$

9. (a) v_N = 900 km/h cos 38.5° = $\underline{704 \text{ km/h}}$, v_W = 900 km/h sin 38.5° = $\underline{560 \text{ km/h}}$

(b) $d_N = 3 \times 704 = \underline{2110 \text{ km}}$, $d_W = 3 \times 560 = \underline{1680 \text{ km}}$.

10. $v_x = 6 + 3 = \underline{9}$, $v_y = \underline{4}$, $v_z = 8 - 3 = \underline{5}$.

$v = [9^2 + 4^2 + 5^2]^{\frac{1}{2}} = \underline{11}$

11. (a) $v_3 = -(v_1 + v_2) = \underline{(-9, -4, -5)}$

(b) $v_3 = v_2 - v_1 = \underline{(-3, 4, -11)}$

12. First write down components. $A_x = 44 \cos 28^\circ = 38.8$; $A_y = 20.7$.
$B_x = -26.5 \cos 56^\circ = -14.8$; $B_y = 26.5 \sin 56^\circ = 22$. $C_x = 0$; $C_y = -31.0$.
$X = A_x + B_x + C_x = \underline{24}$; $Y = A_y + B_y + C_y = \underline{11.7}$. $R = \underline{26.7}$, $\theta = \underline{26^\circ}$.

13. $A_x - C_x = 38.8$; $A_y - C_y = 51.7$. $R = \underline{64.6}$, $\theta = \underline{53.1^\circ}$.

14. $B_x - A_x = -53.6$; $B_y - A_y = 1.31$. $R = \underline{53.6}$, $\theta = \underline{178.6^\circ}$.

15. (a) $A_x - B_x + C_x = 53.6$; $A_y - B_y + C_y = -32.3$. $R = \underline{62.7}$, $\theta = \underline{-31.1^\circ}$, i.e. below x–axis.

(b) $A_x + B_x - C_x = 24$, $A_y + B_y - C_y = 73.7$; $R = \underline{77.4}$, $\theta = \underline{71.9^\circ}$.

16. (a) $3.80 \sin 30^\circ = \underline{1.9 \text{ m/s}^2}$.

(b) For vertical motion, use eq (2–10b). $250 = 1.9t^2/2$, $t = \underline{16.2 \text{ s}}$.

17. $86.6^2 = 35.4^2 + Y^2$, $Y = \pm 79.0$. $\theta = \arctan(\pm 79/35.4) = \underline{\pm 65.9^\circ}$

18. The north component = 4850 m cos 38.2 = 3810 m
The west component = 4850 sin 38.2 = 3000 m.
The components of the vector from camp to summit $\underline{(-3000, 3810, 2250)}$
Displacement vector = $\sqrt{-3000^2 + 3810^2 + 2250^2} = \underline{5346 \text{ m}}$.

19. $\mathbf{v}_{CW} = \mathbf{v}_{CB} + \mathbf{v}_{BW}$ (C – cat B – boat W – water)
$\mathbf{v}_{CW} = (1.8 + 6.6)\text{m/s} = \underline{8.4 \text{ m/s}}$ (direction of boat)
If the cat were walking in the opposite direction,
$\mathbf{v}_{CW} = -1.8 \text{ m/s} + 6.6 \text{ m/s} = \underline{4.8 \text{ m/s}}$ (direction of boat)

20. $\mathbf{v}_{PE} = \mathbf{v}_{PS} + \mathbf{v}_{SE}$ (P = passengers S – ship E – Earth)
$\mathbf{v}_{PE} = \sqrt{4^2 + 13.2^2} = \underline{13.8}$ ~~m/s~~ km/h

21. (a) $(3.1^2 + 1^2)^{\frac{1}{2}} = \underline{3.26 \text{ m/s}}$. $\arctan(3.1/1.0) = \underline{72.1^\circ}$ to bank, downstream.

(b) Displacement is $(3.26)(4) = \underline{13.0 \text{ m}}$, at $\underline{72.1^\circ}$ to bank.

22. Relative speed is 160 km/h. Time is (10 km)/(160 km/h) = 0.0625 hr = 3.75 min.

23. (a) North component of plane velocity is (300 + 50 cos 45°) km/h = 335 km/h.

East component is 50 sin 45° = 35.4 km/h. Velocity is $(335^2 + 35.4^2)^{\frac{1}{2}}$ = 337 km/h.
Direction is arc tan (335/35.4) = 84° north of east.

(b) The wind is moving the plane off course. In 0.5 h it moves it (50 km/h)(0.5 h) 25 km in NE direction from point where it is expected to be. It is a perpendicular distance of (25 km) cos 45° = 17.7 km from its imagined course.

24. $v = [(1.85)^2 - (1.20)^2]^{\frac{1}{2}}$ = 1.41 m/s.

25. (a) Upstream component of boat, 3.35 sin 35.5°, must cancel current; so current speed = 1.95 m/s

(b) 3.35 cos 35.5° = 2.73 m/s.

26. Component of speed across river is (1.80 m/s) cos (45°) = 1.27 m/s
Time to cross river is (260 m)/(1.27 m/s) = 204 s
Speed upstream is (110 m)/(204 s) = 0.538 m/s
Stream speed is [(1.80) sin (45°) − 0.538]m/s = 0.734 m/s

27. (a) Time in water is (200 m)/(1.20 m/s) = 166.7 s.
Distance swept downstream is (0.80 m/s)(166.7 s) = 133 m

(b) 167 s

28. Measuring from a perpendicular to the bank, (1.20 m/s) sin θ = 0.80 m/s
θ = 41.8°

29. $v_{12} = v_1 - v_2 = (60) - (40) = \vec{v}_{12} = \vec{v}_1 - \vec{v}_2$ has magnitude 72 km/h, at θ = 34° from $\perp$. "head–on–ward" of left (or right)
$v_{21} = -v_{12}$ has magnitude 72 km/h, at θ = 56° from $\perp$ "head–on–ward" of right (or left)

The direction is 34° from car 1's direction of travel towrd the direction from which car 2 is coming.

30. The pilot must cancel the wind component perpendicular to his desired direction. Let him swing the plane θ off course into the wind; i.e. to the north. Then (480 km/h) sin θ = (100 km/h) cos 28°. θ = 10.6°. The pilot points plane 38.6° N of E.

31. Intitially relative speed is 10 km/h. Use eq (2–10b). 50 m = (2.78 m/s)10 s + 0.5 a (10 s)^2; thus a = 0.444 m/s^2.

32. Initial relative speed = −40.0 km/h = −11.1 m/s
Distance speeder is past policeman is (11.1 m/s)(1.00 s) = 11.1 m initially.
Use eq (2–10b). 11.1 m = −(11.1 m/s)t + 0.5(2.00 m/s)t^2, t = 12.0 s
Altogether then 1.00 s + 12.0 s = 13.0 s

33. Initially relative speed is (25 − v). Hence v − 25 = (25 − v)6 + 0.5(2)(6)^2. v = 30 m/s or 108 km/h.

34. For vertical motion, use eq (2–10b). $h = gt^2/2$ = 19.6 m.
For horizontal motion, use eq (2–10b). x = (1.8 m/s)(2 s) = 3.6 m.

35. For vertical motion, use eq (2–10b). 15 = $gt^2/2$. Hence t = 1.75 s.
Distance from base is (4 m/s)(1.75 s) = 7.0 m.

36. Similar to Ex. 3–8, $R = v_0^2 \sin 2\theta_0/g$. $16 = 13^2 \sin 2\theta_0/9.8$. θ_0 = 34° or 56°.

37. Time is 24/21 = 1.14 s. $h = gt^2/2$ = 6.4 m.

38. The horizontal compoenent of velocity does not change. In the vertical direction as the displacement is zero, eq (2–10c) gives $v^2 = v_0^2$. As the components have same magnitude the speed is the same. Note initial vertical component is up, final vertical component is down so velocities are not equal.

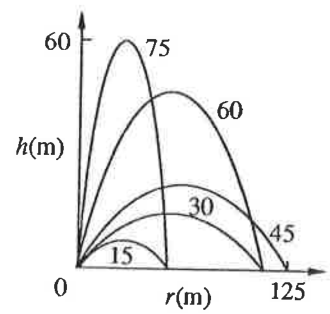
39. No vertical displacement. Use eq (2–10b). 0 = (17 m/s)(sin 40)t − (9.8 m/s^2)t^2/2. t = 2.23 s.

40. For horizontal motion use eq (2–10b). 170 = 450t, t = 0.378 s.
For vertical motion, use (2–10b). h = 0.5(−9.8)(0.378)^2 = −0.699 m.

41. For vertical motion use eq (2–10b). −2.2 m = (14 m/s)(sin 40°)t + 0.5(−9.8 m/s^2)t^2. t = 2.06 s.
For horizontal motion use eq (2–10b). x = (14 m/s)(cos 40°)(2.06 s) = 22 m.

42. For vertical motion up use eq (2–10b). $0 = v_0 - gt$. $t = \underline{v_0/g}$. Eq (2–10c) gives $h = v_0^2/2g$. For motion down use eq (2–10b). $-h = -v_0^2/2g = -gt^2/2$. Thus $t = \underline{v_0/g}$.

43. For vertical motion, $t = 2\, v_0/g \sin\theta$.
For horizontal motion, $x = v_0 \cos\theta\, t = (v_0^2/g) \sin 2\theta$.
As $\sin 2\theta = \sin(180 - 2\theta)$, θ and $90 - \theta$ give same projectile range.



44. Monkey height h off ground d away. Angle θ of gun such that $\tan\theta = h/d$. Let H be height of bullet as it passes tree. Time of flight $t = d/v \cos\theta$. $H = v \sin\theta(d/v\cos\theta) - gt^2/2 = h - gt^2/2$. Height of monkey t secs after dropping $= h - gt^2/2$. Thus monkey and bullet have same vertical and horizontal displacements. Bullet hits monkey.

45. From Problem 43, Range $= \dfrac{v_0^2 \sin 2\theta}{g}$.

$$\sin 2\theta = \frac{Rg}{v_0^2} = \frac{(30\text{ m})(9.8\text{ m/s}^2)}{(35\text{ m/s})^2} = 0.240 \Rightarrow 2\theta = 13.9^\circ$$

$\theta = \underline{6.9^\circ}$ above horizontal.

46. Range $= (v^2/g)\sin 2\theta$, problem 43. $v^2 = (8.9\text{ m})(9.8\text{ m/s})/\sin 60$, $v = \underline{10\text{ m/s}}$.

47. (a) For vertical motion, use eq (2–10b),
$-140 = (100 \sin 37^\circ)t + 0.5(-9.8)t^2$,
$t = \underline{14.3\text{ s}}$.

(b) $x = (100 \cos 37^\circ)(14.3) = \underline{1140\text{ m}}$.

(c) $v_x = 100 \cos 37^\circ = \underline{79.9\text{ m/s}}$.
$v_y = (100 \sin 37^\circ) + (-9.8)(14.3) = \underline{-79.9\text{ m/s}}$.

(d) $v = (79.9^2 + 79.9^2)^{\frac{1}{2}} = \underline{113\text{ m/s}}$.

(e) $\theta = \arctan(-79.9/79.9) = \underline{-45^\circ}$.

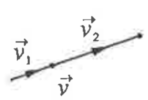
48. (a) The plane and supplies have same horizontal motion, therefore when plane is over victims, so will the supplies be. To arrange that supplies are on ground use eq (2–10b). $200 = 9.8t^2/2$, $t = 6.39$ s. distance in advance $= (69)(6.39) = 441$ m.

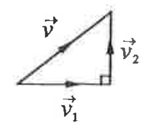
(b) $t = 400/69 = 5.80$ s. Use eq (2–10b) for vertical motion. $200 = v_0(5.8) + 0.5(9.8)(5.8)^2$, $v_0 = 6.06$ m/s, downward.

(c) $v_x = 69$ m/s, $v_y = 6.06 + (9.8)(5.8) = 62.9$ m/s, $v = (69^2 + 62.9^2)^{\frac{1}{2}} = 93.4$ m/s.

49. Vertically down $V_y = gt$. $\tan\theta = (V/V_H) = -gt/v_0$.

50. (a) They are parallel. $\vec{V} = \vec{v}_1 + \vec{v}_2$ (b) They are perpendicular. (c) $v_2 = 0$, $\vec{v} = \vec{v}_1$



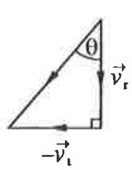


51. The components are 18 m north, 25 m east, 36 m up.

The length is $((18\text{ m})^2 + (25\text{ m})^2 + (36\text{ m})^2)^{\frac{1}{2}} = 47$ m. The vector points at

arc tan (18/25) = E 35.8°N and upwards at arc tan $[36/(18^2 + 25^2)^{\frac{1}{2}}]$, i.e. horizontal 49.4° up.

52. Velocity of raindrops relative to train is $\vec{v}_r - \vec{v}_t$. $v_r = v_t \cot\theta = \dfrac{v_t}{\tan\theta}$.



53. $\overrightarrow{V_{ag}} = \overrightarrow{V_{ap}} + \overrightarrow{V_{pg}}$
Resolve in south and west components.
V_{ag}/south $= (-40 + 26.7\cos 45)$ km/h $= -21.1$ km/hr
V_{ag}/west $= 26.7$ km/h $\cos 45 = 18.9$ km/hr
V_{ag}(magnitude) $= \sqrt{(18.9)^2 + (21.1)^2}$ km/h $= 28.3$ km/h

$\theta = \tan^{-1}\dfrac{18.9}{21.2} \Rightarrow \theta = 41.7°$ W of N.

The velocity of the wind is 28.3 km/h, and 41.7 W of N.

54. (a) Automobile overhauls train at speed 24 km/h.
Time taken is (1 km)/(24 km/h)/(1 h/3600 s) = 150 s. Distance is (25 m/s)(150 s) = 3750

(b) Automobile passes train at speed of 156 km/h.
Time taken = (1 km)/(156 km/h)/(1 h/3600 s) = 23.1 s. Distance is 578 m.

55. For horizontal motion t = (8 m)/(9 m/s) = 0.89 s; time $(t/2)$ to reach his, 0.445 s. But from problem 42, $h = v_0^2/2g = (v_0/g)^2(g/2) = t^2g/2$ = 0.97 m.

56. Range = $(v^2/g) \sin 2\theta$, problem 43; $\frac{R_M}{R_E} = \frac{g_E}{g_M} = 6$.

57. Use eq (2–10b) for horizontal motion, $(v_0 \cos 35°)t = 100$.
Then for vertical motion. $(v_0 \sin 35°)t - 0.5(9.8)t^2 = 12 - 1 = 11$.
$100 \tan 35° - 4.9t^2 = 11$, i.e. $t = 3.5$ s
$v_0 = 100/\cos 35°/3.5$ = 35 m/s.

58. (a) Time is $(D/2)/(v - u) + (D/2)/(v + u) = Dv/(v^2 - u^2)$

(b) $v \sin r = u$. Time is $D/(\cos \theta) = D/(v^2 - u^2)^{\frac{1}{2}}$.

59. Relative to the car the helicopter is flying at 200 km/h – 130 km/h = 70 km/h = 19.4 m/s.

Vertical motion given by eq (2–10b). 88.0 m = $\frac{1}{2}(9.8\ \text{m/s}^2)t^2$, $t = 4.24$ s

Horizontal distance is ((9.4 m/s)(4.24 s)) = 82.4 m
Angle below horizontal = arc tn (88.0 m/82.4 m) = 46.9°

60. Vertical motion 0.5 m = $v(\sin 35)t - (4.9\ \text{m/s}^2)t^2$. Horizontal motion either t = (12.2 m/v cos 35) or (11.8 m/v cos 35). Then eliminating t gives v = 11.6 m/s, or 11.4 m/s.